The agreement of the maximum frequency as well as that of the maximum motion with Stream I is quite remarkable, when we take into account the small number of stars available (88), the more so as λ is only 13°; the influence of Stream II also, although not so strong, can be plainly seen.

More material for different parts of the sky will of course be necessary before we can conclude with any certainty that stars as faint as the 14th and 15th magnitudes show the stream-motion.

[1] van Maanen, Adriaan, *Mt. Wilson Contr.*, No. 167, 1919.

[2] van Maanen, Adriaan, *Astr. J., Albany, N. Y.*, **27**, 1912 (139–146).

[3] Buisson, H., Ch. Fabry, and H. Bourget, *Astrophys. J., Chicago, Ill.*, **40**, 1914 (241–258).

[4] Eddington, A. S., *Steller Movements, London,* 1914, page 100.

ON THE USE OF THE SPECTROSCOPIC METHOD FOR DETERMINING THE PARALLAXES OF THE BRIGHTER STARS

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When the method of deriving the luminosities and the parallaxes of stars by means of the intensities of certain lines in their spectra was developed by Adams and Kohlschütter a few years ago the applicability of the method to the stars of highest luminosity and smallest parallax was necessarily somewhat uncertain. This was due to the fact that the method depends upon the calibration of a scale of line-intensities by means of stars of known parallax and magnitude, and that at this time the observational material for stars of small parallax was necessarily scanty and subject to relatively large percentage errors. All that could be done was to select a few stars with the best parallaxes, so far as could be estimated, and base upon them a set of provisional reduction-curves for the spectroscopic determinations. As a result the values for the absolute magnitudes derived in this way while sufficiently accurate to indicate clearly that the parallaxes of certain stars were very small were not of such a quality as to show in all cases the slight differences between individual stars of small parallax.

The situation has improved greatly in recent years. On the one hand the parallaxes of a large number of stars have been measured with high accuracy by various observers with the aid of photographic methods. On the other hand the amount of spectroscopic material for the stars of various magnitudes and proper motions has accumulated to such an extent that use can be made of the extremely valuable method of determining mean parallaxes for groups of stars from the parallactic motion. Accordingly it has now become possible

to subject the spectroscopic method to a rigorous test of its applicability to the stars of high luminosity and small parallax. The importance of this question is evident when we consider that the trigonometric method of measurement with a probable error which is nearly independent of the size of the parallax can give but approximate values of the absolute magnitude for stars of very small parallax. Thus if the measured parallax of a star of the fifth magnitude is $+0''.010 \pm 0''005$ its absolute magnitude may lie anywhere within the limits -1.5 and $+0.9$, and for smaller parallaxes the range is much larger. Since a great majority of the brighter stars in the sky have small parallaxes the use of the spectroscopic method in which the error is more nearly proportional to the size of the parallax is of fundamental importance for such cases.

As a first step in the investigation a new determination of the constants of reduction for the intensities of the spectral lines was made in 1918 with the aid of the large number of measured parallaxes then available. The absolute magnitudes based upon this system have been divided into groups and comparisons have been instituted with the values obtained from parallactic motion and all available measured parallaxes. In this way we can determine whether the absolute magnitude varies continuously with the line-intensity; and it is possible to use a large number of measured parallaxes including stars of different proper motion and apparent magnitude.

The results of the comparison are shown graphically in the accompanying figures. The spectroscopic absolute magnitudes M_s are plotted as abscissae, the line-intensities being indicated on parallel axes. The absolute magnitudes M_c derived from measured parallaxes and from parallactic motion are plotted as ordinates. The full-line curve represents the values computed from parallactic motion; the broken curve those from measured parallaxes. The wide break in the curves for the K_4–K_9 and the M stars are due to the well-known division of these stars into the giant and dwarf classes.

It is at once evident that the computed absolute magnitudes vary continuously with the spectroscopic magnitudes quite as well among the stars of highest luminosity as among the fainter stars. In fact the largest discordance is found not among the brighter stars but among some of the faintest stars of groups A_7 to F_8 where the luminosities as computed from measured parallaxes show but little variation with line-intensity and for the very faintest stars appear to act in the wrong direction. It is to be noted that in this comparison the more accurate result for the more distant stars is given by the parallactic motion and for the nearer stars by the measured parallaxes.

It is clear that if there are no systematic corrections to be applied to the spectroscopic absolute magnitudes used in this comparison the curves should consist of straight lines with an inclination of 45°. The results show that these corrections are relatively small and that the spectroscopic criteria hold throughout the range of magnitude investigated.

It should be realized fully that the method of deriving parallaxes from the intensities of the spectral lines depends for its accuracy upon our knowledge of the parallaxes of the stars used for the determination of the relationship between absolute magnitude and line-intensity. It is a process of approximation in the early stages of which the corrections may be considerable, but which

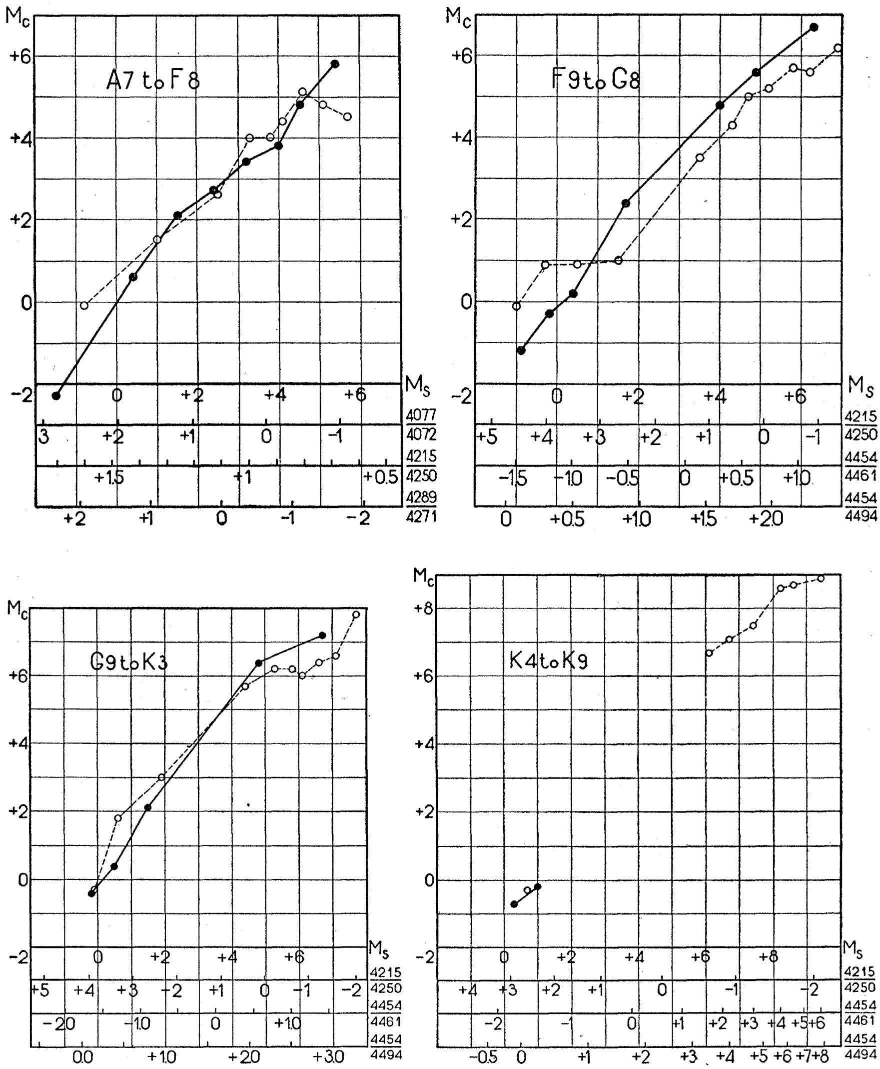

FIG. 1. CURVES SHOWING THE RELATIONSHIP OF THE SPECTROSCOPIC ABSOLUTE MAGNITUDES (M_S) TO THE MAGNITUDES AS DERIVED FROM PARALLACTIC MOTION AND MEASURED PARALLAXES (M_C)

The line intensities upon which the spectroscopic magnitudes are based are also given as abscissæ.

gains more and more in accuracy as the material upon which it is based becomes larger and more reliable.

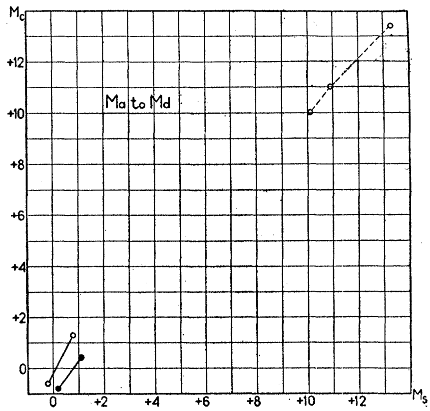

FIG. 2

To illustrate the present state of agreement between the spectroscopic and the trigonometric parallaxes the following table is added for purposes of comparison. The stars are divided into groups and the limits of proper motion for each group are given under the heading μ. The symbols, $\overline{M}$ and $\bar{\pi}$ represent the average absolute magnitude and parallax, respectively. The last column of the table shows the differences between the spectroscopic and the trigonometric parallaxes. The agreement may certainly be regarded as satisfactory in view of the number of stars involved.

Apparent Magnitudes 3.5 to 6.5

μ	No.	$\overline{M}$	$\bar{\pi}_{spec.}$	$\bar{\pi}_{trig.}$	$\bar{\pi}_s-\bar{\pi}_t$
≦0″020	23	−0.4	0″009	+0″008	+0″001
0″021–0″040	19	+0.2	0.013	0.007	+0.006
0.041–0.070	36	+0.3	0.013	0.016	−0.003
0.071–0.100	29	+0.7	0.016	0.021	−0.005
0.101–0.150	38	+0.8	0.021	0.026	−0.005
0.151–0.200	31	+2.3	0.039	0.038	+0.001
0.201–0.300	35	+2.7	0.042	0.043	−0.001
0.300–0.500	51	+3.2	0.042	0.042	0.000

In conclusion a few words may be added about the extent to which the spectroscopic method of determining parallaxes has been applied at Mount Wilson. Between 1500 and 1600 stars have now been investigated in this way including nearly all stars with trigonometric parallaxes and an extensive list of those with very large and very small proper motions. It is of interest to note that in this large amount of observational material hardly a single serious contra-

diction has been found between the spectroscopic and the trigonometric results. This is the more remarkable since we should expect occasional idiosyncracies in the spectra of stars subject to exceptional physical conditions, and the rareness of such cases is interesting evidence for the uniformity of the development of stellar spectra in general.

RELATION OF COLOR TO INTRINSIC LUMINOSITY IN STARS OF THE SAME SPECTRAL TYPE

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It has long been known that the color of a star is intimately related to its spectral type. More recently it has been found that color is also correlated with intrinsic brightness.[1] Thus, two stars having different luminosities, but the same spectrum so far as the usual criteria are concerned, may differ in color-index by more than half a magnitude.[2]

The phenomenon is perhaps to be accounted for as follows: Similarity in spectrum implies at least approximate equality in surface brightness. Difference in luminosity is therefore mainly a matter of size, the brighter object being the larger. But inequality of dimensions doubtless entails differences in atmospheric constitution, and hence also in the selective absorption occurring in the atmospheres. Since color is determined by the distribution of intensity in the continuous spectrum, while type relates more particularly to the characteristics of the spectral lines, one star may thus appear redder or bluer than another, although both are of the same type.

But whatever the explanation, an extension of the results of Adams, van Rhijn, Monk, and others to include a wide range of luminosity for each spectral type is immediately desirable, because of their bearing upon the difficult problem of stellar constitution. Further, any phenomenon correlated with stellar luminosity should be studied to the utmost, on account of its possible importance for the determination of interstellar distances. If the intrinsic brightness of a star can be found, the problem of its parallax is solved.

The method employed for the measurement of color in securing the preliminary results here described is that of exposure-ratios[3], which is convenient and reliable, and much more expeditious than the direct determination of color-index.

An isochromatic plate exposed behind a yellow filter records the intensity of the 'yellow' light received from the star. The same plate used without filter registers the 'blue' light; the longer wave-lengths are then also active, but the image, nevertheless, is essentially blue, owing to the relatively great blue-sensitiveness of the isochromatic plate. In neither case are we dealing with monochromatic light, or even with a very narrow range of color. That, how-